The Use of Formal and Informal Learning Environments by Students with Physical Difficulties.

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ABSTRACT

This study is the first part of an evaluation report of the project Connect, which will be presented after the completion of the implementation of the program in the participating schools. This study briefly presents the features of the program and the conclusions drawn after the 1st phase of the research, which was carried out by the students of the Special Senior High School of Athens, one of the schools that will pilot the program.

KEY WORDS: *the classroom of the future, students with physical needs, CONNECT.*

INTRODUCTION

CONNECT[1] is co-funded by the European Union within the program "Information Society Technologies (IST)" of the Sixth Program Framework. Its basic aim is to develop an innovative pedagogical framework, which tries to connect both formal and informal learning, suggesting the reformation of Natural Sciences teaching and the creation of a European museum network as well as scientific centers and schools, in order to develop, implement and evaluate innovative ways of teaching (Ouzounoglou et al., 2004). This specific project suggests an innovative pedagogical approach that aims at connecting the traditional lesson and the existing analytical program (formal learning) with educational visits and activities taking place in a scientific center and relying on the students' free choice to try out some or all the exhibits and elaborate or not on the concepts and phenomena that are described by it (informal learning)(figure 1). This suggested approach refers to concepts and phenomena which are vague and difficult for students to understand and tries to connect their teaching with the presentation of these concepts and phenomena through the exhibits and experiments of the scientific center. These, usually, are difficult to understand because they appear in symbols, they are not connected to activities carried out by the students and, most importantly, are not visual, they do not have a visual entity (Anastopoulou, 2004). In order to achieve that, we apply the use of augmented reality technology, something which allows the visualization of phenomena and concepts that are not visible by the naked eye(figure 2a).

[1] The CONNECT cooperation consists of the following participating parties: National Technical University of Athens, Ellinogermaniki Agogi, Evgenides Foundation (Greece), Fraunhofer Institute of Technology, University of Duisburg, University of Education Ludwigsburg (Germany), ECSITE, INTRASOFT (Belgium), Vaxjo University (Sweden), University of Birmingham, @BRISTOL (HB) (Greece), HEUREKA (Finland) Institute for Learning Innovation (USA), LEGO (Demnark), Weizman Institute of Science (Israel).

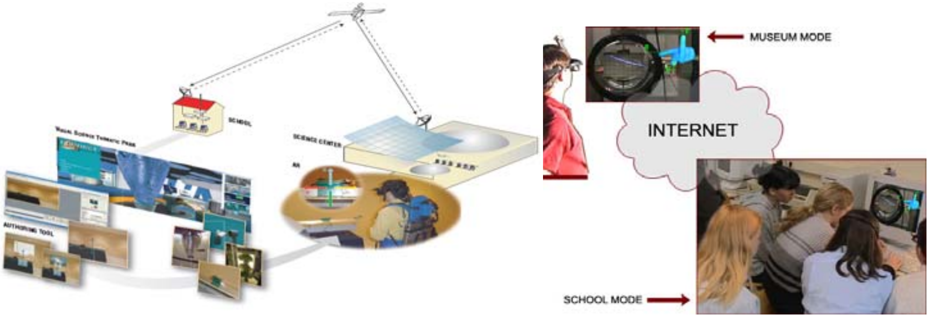
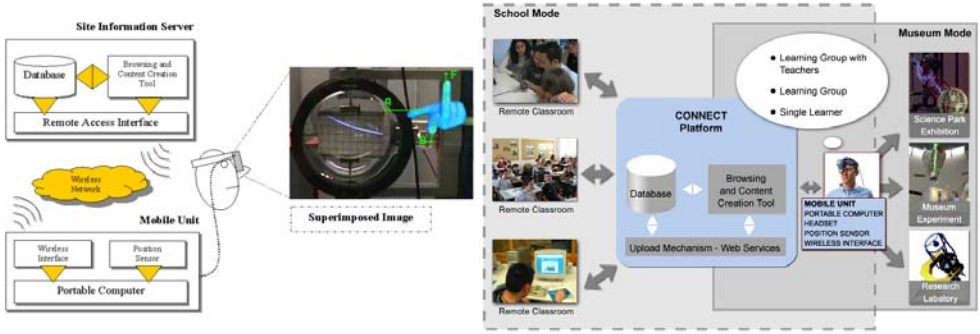


Figure 1:2 function modes, with physical appearance and through internet platform from school



2(a) **2(b)**

Figure 2:Connect's operation

Teaching Natural Sciences to students with physical disabilities

Students with physical disabilities are a large group of the global student population, which is itself complex and heterogeneous[2]. A large percentage of them cannot have an autonomous existence within the school environment and a "normal" participation in a usual everyday school day, whereas their response to the analytical school timetable is considered very difficult. The possibility to explore individually the environment (the classroom, the wider school area, the facilities provided for school happenings of any kind) is very little. Thus, in order to respond to school life, they need extra, additional support. The information technology has the tolls and means to help, providing 3 types of access: physical, cognitive and supportive (Day, 1995). Technology allows for the creation of new ways for education and expression for people with kinetic disabilities. Studies have shown that computers, and modern technologies, in general, have a lot of advantages for children with physical disabilities, offering them many experiences and helping them evaluate their abilities

[2] Physical motion is directly related to the child development; it affects a child's more general learning abilities both in the first stages of its development and later on. Research claims there is a relation between the kinetic and mental development of the child (Wall, 1985). Those pupils that suffer under physical disabilities leading to serious kinetic problems are bound to face learning difficulties (Koutsouki, 1999) and therefore for such pupils it is recommended to take up an individual educational program (IEP), which is specifically designed to meet their educational needs.

(Northwest, SEMERC, et al., 1992). Through the right choice of a program they can have the ability to live whatever is "forbidden" in real life and, from onlookers, they can become participants and later on creators (Banes et al., 1995). The use of virtual reality supports this very part (European Conference on Disability, 1998).

Contemporary pedagogic science claims that teaching should be guided by a holistic approach that takes into consideration the learning process of the children, the subject that should be taught and the teaching methodologies. A large number of teachers and tutors underline the importance of visualization and practical experience as important elements in the teaching process (Bransford et al., 1999). When the optional activities concerning natural sciences are introduced in the analytical program, this magnifies the influence of the information provided since the interest that the students show is being augmented and the information is "delivered" rather recently. The informal learning which is carried out in "empirical" environments, such as technological and scientific museums, should be combined with formal learning as it is carried out within the school environment. In this way, it is possible to make learning a process of discovery and participation, which will be based mainly on the motivations of the students (informal learning) and not on the barren passive knowledge of the curriculum and the mere presentation of rules (formal learning) (Sfard, 1998). It has been observed that when natural concepts are taught, there is a number of misunderstandings concerning mainly concepts which can be scientifically researched. The introduction of informal learning experiences in the analytical program can contribute to a great extent, helping students to develop critical ability and a deeper understanding of the concepts that can be scientifically researched, thus improving greatly the way different and heterogeneous groups of people can approach and understand natural sciences (Coombs, 1985, King, 1996).

Students with special educational needs and the CONNECT project

Based on the facts of the Greek -as far as the special schools for physically disabled children and the existing curriculum- as well as of the European reality[3], and, also the concerns regarding the creation of the classroom of tomorrow, this research aims at finding the best possible way to help children with physical disabilities exploit technology within their educational activities and create suitable activities so that we can promote the cooperation between them, their socialization process and their ability to fit in life and be prepared to enter normal classes. The students of the Special High School of Athens participated in CONNECT so that AR[4] technology, which is now under development, can take into consideration the needs of all students, both with and without physical disabilities. The future classroom is designed in such a way that all students/users will feel and actually be equal and tries to take measures to cover all possible educational needs.

The idea of CONNECT, as well as its implementation, is believed to enable the continuum *Onlooker⇒Participant⇒Creator*, thus opening new ways to help pupils acquire more control over their learning. It also helps them acquire a more active role in the use of new technologies, through experimentation, learning and helping the teacher identify the misconceptions that may be relating to any subject.

[3] The European Community believes that it is absolutely imperative that those children are integrated in normal classes and special schools are abolished (turned into "education centers") and addresses mainly students who are unable to attend the analytical school program.

[4] AR= augmented reality

The basic principle of the relation between technology and physically disabled students, as it is defined by Hawkridge A. & Vincent (1992), is fulfilled, and the possibility of integration and communication by means of learning and actual experience seem to have been covered. The Virtual Thematic Park of Sciences makes use of tools of augmented reality so that three-dimensional objects and recreations are projected for the students to see with the use of portable devices and they are incorporated within the natural habitat of the museum in an exhibit or an experiment. In this way, many "invisible" parameters of the natural phenomena (e.g. the forces, the fields, the waves, the sums in Physics) will be visualized so that the students can better understand them. This interactive experience is recorded in a laptop and the next day after the visit it can be projected on a video wall so that all members of the school community can share the experience of seeing it. Every student in the school can make a virtual reality visit to the museum and has the ability to choose a different program of guiding through the system of augmented reality (figure 2).

Description of the 1st experimental phase: Methodology and Research Conditions

A learning scenario is a description of student's interactions with the exhibit with the aid of the CONNECT technology. Each scenario has been designed in collaboration of what has been produced by the technical partners. The user centred approach of the CONNECT project implies that students will use the mobile AR system and the CONNECT platform(figure 2b) during their virtual and/or conventional field trips according to the pedagogical pathways, i.e. the standard visit pathway, the remote-school visit pathway and the school exchange pathway. During the **first cycle** of the pilot applications, the first prototype was tried in three pilot sites, in at-Bristol, UK, Heureka, Finland, Experiment Huset, Sweden. During the **second cycle** of pilot applications, the developed system applied through well-defined educational scenarios in four pilot sites, in 'at-Bristol', UK, 'Heureka', Finland, 'Xperiment Huset', Sweden., 'Eugenides Foundation', Greece. This run had a three-month duration and students', teachers' and museum staff's reactions to the proposed pedagogical approach was monitored and currently being analysed in detail. These two first pilots with the users will be performed with scenarios that will be developed by the project's pedagogical team. The main purpose of these phases was to get users familiarized with the new approach and the new tools (hardware and software) and prepare them for the final and most important cycle of the user-centred work, the five-month second phase of the Final Run, the implementation of the open educational pathways. With the experience gained during the Test Run and after the appropriate modifications on both the educational tools and on the educational approach, the partnership will implement the project in real environments during a five-month cycle, the **Final Run**. The open architecture of the CONNECT platform allow for the adoption of the new ideas in short time.

The scenario that was selected in Greece for the 1rst run was the study of the function of friction; the exhibit was the Air Track. 5 classes of 3 different Greek schools took part, 3 as experimental team and 2 as test team. There were total 106 students aged 15-16, from them 9 were students with physical disabilities from the "Special School of Athens for students with physical impairments".

Having the results from the first experimental cycle, all the necessary modifications will be made in order to improve the educational tools, the augmented reality equipment (location identification system, projections, etc), the software and the CONNECT platform, and, finally, the learning approach. After that, the program will be tested during the cycle of the final applications.

Description of the team – Population characteristics

The research team consisted of students from a class of the Senior High School. Those students did not have any particular learning difficulties, they are considered to be a "well-taught" class, having a good cooperation as a team, among them and with their teachers, and active competitiveness. They are quite good in subjects relating to computers and new technologies, they respond positively to new experiences and teaching approaches, as well as to cooperation with other teenagers of their age in various programs. Finally, they ask for communication and knowledge[5]. As to the kind of kinetic disorders, the group was consisted of five muscle disorders of the Duchene type, one athrogriposis, four brain paralyses (two of which is accompanied by epilepsy)(table 1). The composition of the group according to gender was 4 female and 6 male. The age of those students was between 15 – 19 years old.

Participant	*Age*	*Sex*	*Disability*
1	16	M	M.D.
2	15	F	M.D.
3	18	F	C.P[6].
4	16	M	M.D.
5	18	M	Arthrogryposis
6	16	F	C.P.
7	17	F	C.P.
8	17	M	M.D.
9	18	M	C.P.

Table 1: Details for participants in wearability evaluation

Activities- First Results

The first phase was conducted by the Physics teacher of the school, within the curriculum of the lesson of Physics, and the points that were discussed were the following: A) Why we have Friction, B) its role in everyday life [examples were given regarding what would happen if it did not exist (i.e. we could not walk or stop)], C) factors that influence the increase or reduction of friction. Pictures and videos were used in order to be better understood. In this phase, we had participating observation. The first visit was scheduled for the 20th December 2005. 2 students were absent in the experimental phase due to illness, who tried out the AirTrack on February 1st 2006. Of the students that were present, only one schoolgirl did not try out the exhibit, because her parents did not approve. Her participation was restricted to the process where the use of AR was not necessary. The same happened to a student of the 3rd grade of the Senior High School, who, because of his affluence for technology, was thought better to participate during the second visit (1/2/2006). Before the use of AR, the children were separated in groups of three and are presented with the platform by the person in charge of the program. The teams were randomly formed by the person in charge of the program. The experiment process lasted for about 15 minutes for each student (figure 3). The students' visits were recorded on tape. In each video, the time was broken down to the time needed to prepare the technology for each student, the time that the teacher spoke, the time that the students discussed with the teacher and, finally, the time that the students were

[5] These students usually resign from life and educational processes, they focus on their health problems and a large percentage of them has difficulty in cooperating or functioning as a team.

[6] C.P. = cerebral palsy, M.D. = Muscular Dystrophy

involved with the exhibit or friction. Thus, we have a contrast with the way the students use

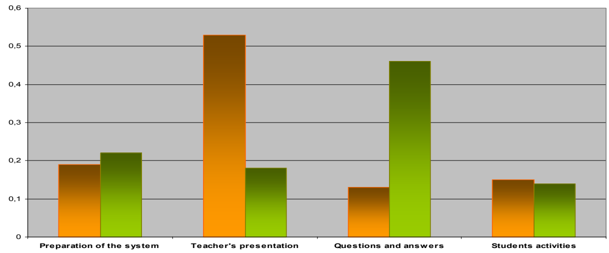
Figure 3:Finction Experiment

the exhibits of the scientific park, since, there, the students “communicate” alone with the exhibits.

Pedagogical evaluation

A systematic evaluation methodology was developed to identify the impact of the proposed approach in the learning procedure. It focuses on locating evidence that proves the effectiveness of integrating informal learning methods to the curricular activities. The answers on the tests from the pre-visit and the post visit are used on the evaluation procedure as well as a questionnaire that was filled in, as soon as the experiment ended. The disable students had almost the same results as the non-disable students in the tests. The misconceptions as they came out from the wrong answers on the pre-visit tests were almost the same and so were the improvements on the post-visit tests. It worth, to be mentioned that one of the students couldn’t understand the theme on the video (hovercraft), the specialists consider it as a result of his limited spurs in his environment. This leads to the conclusion that the scenario should be much more carefully designed and to be taken under consideration the specialities of the students that participate (living condition, previous experiences etc). The students understood in a better way the force of friction and its effects on considering the fact that only 3 of them are independent and not using wheelchair. There was a maldistribution of the time, so the time the students had for their activities was only the 15% of the total, the preparation time was at the 20% and more than 50% was used from the teachers’ presentation as is shown in figure 4. There are no preparation times for the technology used or for the teacher to guide students. It also takes a great deal of time for the students to get prepared for the use of AR.This had to be change since the students should interact with the exhibit as much as they can. They students characterized the procedure as unique, interesting and groove. The cooperated well, in team of the three persons. Measurements made from the psychologist and the researcher at the end of the 1rst run confirmed an increase of the self-esteem at the 7 of the participants that had to do with the feelings of social acceptance and success (figure 5). The other 2 (participants 5 and 8) were in a very bad physical and emotional condition focusing on their disability. After the experiment, there was a change in the dynamic of team, the ties between the weakest students (participant 4and 5) and the rest of the team became stronger.

The teachers that participated noted that the students were encouraged to a great extent with this particular activity: a) they become creators and not just recipients of contents (variety in the scripts, possibility to choose any of them through the menu which is visually presented to them), b) they cooperate and communicate with people that share the same interests, goals and needs (even the sense that other teenagers use the relevant tool and take part in new experiences worked as an extra motivation force even for the most suspicious and skeptical students), c) they comprehend and use the scientific concepts they learn so as to better understand the phenomena they observe in everyday life, and, d) they use the scientific way of thinking in their life.



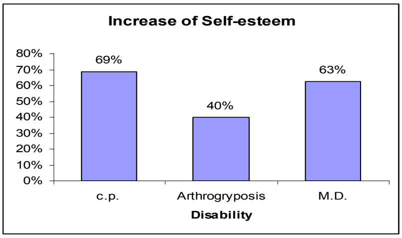


Figure 4:Time Development

Figure 5: Increase of Self-Esteem

Wearability Evaluation

The wearability evaluation of the CONNECT system (figure 6) assesses the effect of the wearable on three aspects. The physiological aspect assesses the energy expended due to the load attached to the body.

Figure 6:Wearable system of Connect

Assessment of the biomechanical aspect focuses on musculoskeletal loading as the device is attached to the body. This may manifest itself in sensations of pain and discomfort, which may be localised to a specific region of the body (Knight & Baber, 2004, Knight & Baber, in press). The results of the wearability analysis which was made from the team of Knight, Arvanitis et al. are shown in tables 2-3. Figures 7-9 show mean data and include able-bodied data (n = 45) from Knight et al., (in review) for comparison. Due to the limited number of handicapped students of the research at this level (consider the fact that 3 of the group couldn't attend the experiment and 2 were not allowed to use the Connect wearable system- table 1), quantitative statistical analysis was not possible, and all analysis made at the descriptive qualitative level.

As far concerning the physiological cost, through ratings of RPE, two participant's level increased from the pre-test to post-test evaluation. The same was observed also for able-bodied users (figure 7), suggesting that the wearable system was fatiguing to wear. One's participant level was decreased, however this was from an extreme level, and the final level was still rated as having a large physiological effect.

For perceptions of discomfort through ratings of general comfort, visual discomfort and sensations of pain, all the participants (except participant 4), perceived a Very Large or Extreme level of effect for at least one variable. These participants perceived very large to extreme levels of effect for Attachment, which is probably due to the weight and fit of the HMD. For able-bodied users, Attachment is often the highest scoring comfort dimension (Figure 8). However, the average Attachment score for wheelchair users was almost twice the average for able-bodied users, suggesting a significant difference between the two groups.

Two of the wheelchair users perceived a considerable emotional effect, suggesting that they were self-conscious or embarrassed wearing the CONNECT system, which is a response similar to able-bodied users. For the other comfort dimensions (Harm, Perceived change, Movement and anxiety), able-bodied users have scored on average slightly higher than the wheelchair users, particularly for perceived change and anxiety. This suggests that wheelchair users feel less different due to wearing the CONNECT wearable system, and are less worried about the system.

For vision effects, visual discomfort, dryness in eyes, irritation in eyes, difficulty focussing and visual fatigue all scored very highly, indicating that the HMD system was considerably stressful on the visual system. This was particularly so for participant 3 as well as for 1 and 5, who also felt generally tired after wearing the system. In Figure 9 the Vision effect scores for wheelchair and able-bodied users are presented. Although the average ratings for these effects were roughly double the average values generated by able-bodied users, they follow a similar pattern of responses reported by able-bodied users, in terms of being the most common symptoms experienced.

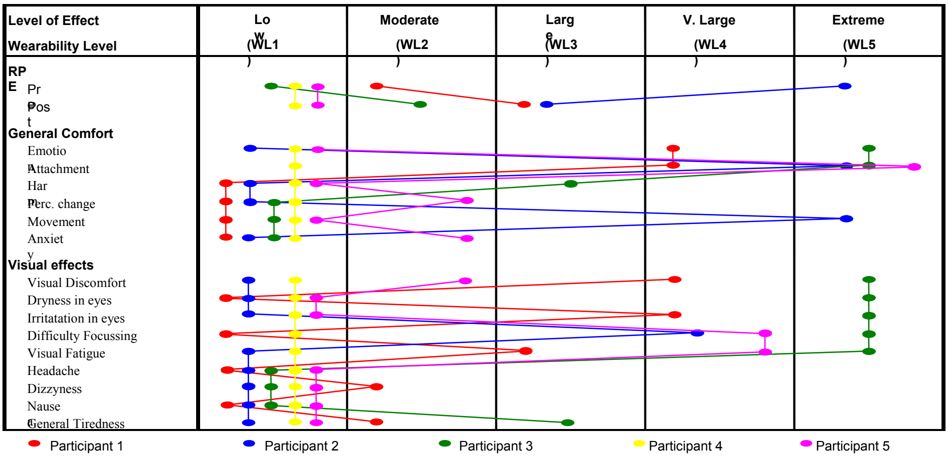
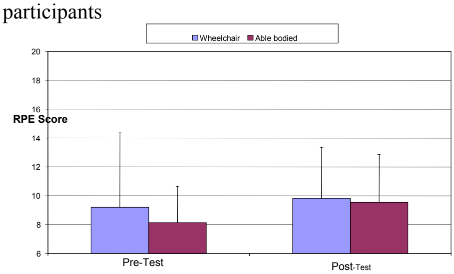


Table 2. Relative Perceived Exertion (RPE), General Comfort and Vision Effects rated by the 5 wheelchair participants



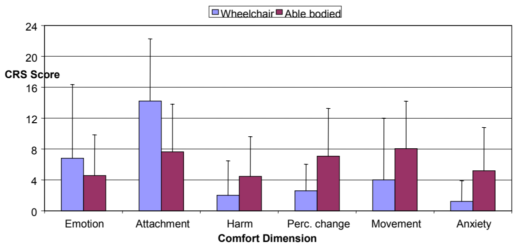


Figure 7. Pre and Post-test RPE scores for wheelchair and able-bodied users. Figure 8. Comfort scores for wheelchair and able-bodied users.

As far as the musculoskeletal pain is concerned, only two participants rated any sensation, which were located on the head and around the waist, for participant 1 and 3 respectively (table 2). For able-bodied users, head discomfort is common as is probably due to the weight of the HMD. However, able-bodied users also often experience discomfort around the shoulders, arms and back, which may be due to supporting the weight of the laptop unit in a backpack. The wheelchair users were not required to wear a backpack, which is why they did not experience any discomfort in these other areas.

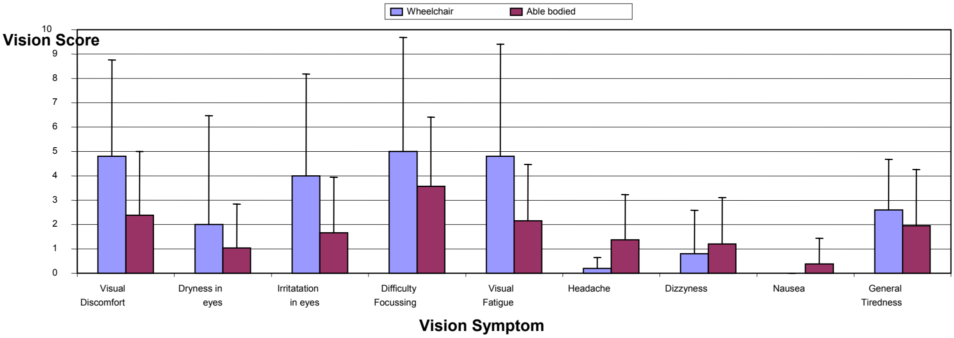


Figure 9. Vision effect scores for wheelchair and able-bodied users.

	Level of Effect					
	Low (WL1)	Moderate (WL2)	Large (WL3)	V. Large (WL4)	Extreme (WL5)	Total
Head	-	*(6)*	**1** *(8)*	*(1)*	-	**1** *(15)*
Face	-	*(1)*	*(1)*	-	-	*(2)*
Neck	-	*(3)*	*(1)*	*(1)*		*(5)*
Collar	-	*(1)*	-	-	-	*(1)*
Left shoulder	-	*(1)*	*(1)*	*(2)*	-	*(4)*
Right shoulder	-	*(1)*	*(1)*	*(2)*	-	*(4)*
Left upper arm	-	*(2)*	-	-	-	*(2)*
Right upper arm	-	-	-	-	-	-
Left lower arm	-	-	-	-	-	-
Right lower arm	-	-	-	-	-	-
Left hand	-	*(1)*	*(2)*	-	-	*(3)*
Right hand	-	*(1)*	-	-	-	*(1)*
Chest	-	-	-	-	-	-
Upper back	-	*(3)*	-	-	-	*(3)*
Mid Torso	-	-	-	-	-	-
Mid back	-	*(2)*	-	-	*(1)*	*(3)*
Waist	-	**1**	-	-	-	**1**
Lower back	-	*(1)*	-	-	-	*(1)*
Total	-	**1** *(23)*	**1** *(14)*	*(6)*	*(1)*	**2** *(44)*

*NB. Value in **Bold** represents the number of particpants reporting any sensation of pain*
Value in brackets is able bodied data from Knight et al., (in review), n = 45

Table 3. Perceptions of pain and discomfort rated by 5 wheelchair participants

Across the participants, observation showed that same of them appeared to be particularly stressed wearing the CONNECT system, with increased RPE and extreme levels of effect for comfort and visual discomfort; whereas, same others rated little effect. This suggests that there is considerable inter-individual difference in the wearabilty of the CONNECT system. Indeed, Knight et al., (in review) have shown that the level of effect for Post-test relative perceived exertion (RPE) and the comfort dimension Harm are related body weight and duration of the trials, which also affects the level of visual fatigue. In addition, there also appear to be sex differences, specifically for the rating of RPE for able body users. Unfortunately, the limited sample size for wheelchair users means that similar relationships cannot be established or investigated, at this stage.

Summary

The Connect project has impact upon the fields of instructional technology, educational systems design and museum education attempt. Its aim is to integrate the use of physical objects that are computationally-augmented and to support and encourage face-to-face interaction between students and virtual objects. Although, the sample size of the physical disable users is limited, the results are important considering the recorder data and the new paths that are opening for further investigation. The recorded effects of this kind of activities on these students and the needs that came up were significant for the effort for a better inclusive school(socialization & smooth adaptation within society, participation in the team, “transcendence” of their condition and their positive attitude towards life, as far as people with special educational needs are concerned). Of course, a lot of matters have to be further examined, about the use of augmented reality in special education. Some of them are: (1) the alternative ways that influence the education beyond the mere use of the computer technology, (2) the contribution in the improvement of their life and the acquire of satisfaction in their heavy school program, (3) the degree of the overcoming the boundaries of their disability,(4) alleviate their isolation, (5) increase their self-esteem and (6) integration with other students in other districts or even nationwide. The degree in which the previous can be achieved is one matter and the other one is the impact on the areas of school life, learning procedure and functionality of the classroom. So, some of the future aims (concerning the people with multiple disabilities) are to design scenarios much more carefully; to improve the wearable system taking under consideration the multiple factors that arouse when disable students are included in any educational procedure, so that the present project fulfills its aims to create a pan-European network of exhibits and museums and contribute to further socialization of people with kinetic disabilities beyond the borders of the classroom, since the Virtual Thematic Park of Sciences has the ambition to become a center of cooperation of a large number of museums and scientific centers as well as schools, which will promote the innovative approach attempted by the CONNECT project and support all those involved in their effort to understand and interact with natural phenomena and concepts. In addition, it should be noted that, due to the small sample size of the wheelchair group, and hence the susceptibility for the data to be skewed by extreme individual responses, comparisons between the two groups (in wearability evaluation), based on the average data, should be taken lightly. As it is, quantitative statistical analysis was not possible, and all analysis made at the descriptive qualitative level. So, further research should be made, for the evaluation of the wearability system. Although, the small size of the physical disable students the results are important, bearing in mind the new potential paths for further work that can be considered.

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